The adoption of sustainable remediation behaviour in the US and UK: A cross country comparison and determinant analysis

CrossMark

Deyi Hou [a,*], Abir Al-Tabbaa [a], Peter Guthrie [b]

[a] Geotechnical and Environmental Research Group, Department of Engineering, University of Cambridge, Cambridge CB2 1PZ, UK
[b] Centre for Sustainable Development, Department of Engineering, University of Cambridge, Cambridge CB2 1PZ, UK

HIGHLIGHTS

- Ranked 27 sustainability considerations in remediation in the US and the UK.
- Ranked promoting factors and barriers of sustainable remediation.
- Identified internal characteristics and external forces affecting GSR behaviour.
- Determined the statistical significance of each factor's effect.

ARTICLE INFO

ABSTRACT

The sustainable remediation concept, aimed at maximizing the net environmental, social, and economic benefits in contaminated site remediation, is being increasingly recognized by industry, governments, and academia. However, there is limited understanding of actual sustainable behaviour being adopted and the determinants of such sustainable behaviour. The present study identified 27 sustainable practices in remediation. An online questionnaire survey was used to rank and compare them in the US (n = 112) and the UK (n = 54). The study also rated ten promoting factors, nine barriers, and 17 types of stakeholders' influences. Subsequently, factor analysis and general linear models were used to determine the effects of internal characteristics (i.e. country, organizational characteristics, professional role, personal experience and belief) and external forces (i.e. promoting factors, barriers, and stakeholder influences). It was found that US and UK practitioners adopted many sustainable practices to similar extents. Both US and UK practitioners perceived the most effectively adopted sustainable practices to be reducing the risk to site workers, protecting groundwater and surface water, and reducing the risk to the local community. Comparing the two countries, we found that the US adopted innovative in-situ remediation more effectively; while the UK adopted reuse, recycling, and minimizing material usage more effectively. As for the overall determinants of sustainable remediation, the country of origin was found not to be a significant determinant. Instead, organizational policy was found to be the most important internal characteristic. It had a significant positive effect on reducing distant environmental impact, sustainable resource usage, and reducing remediation cost and time (p < 0.01). Customer competitive pressure was found to be the most extensively significant external force. In comparison, perceived stakeholder influence, especially that of primary stakeholders (site owner, regulator, and primary consultant), did not appear to have as extensive a correlation with the adoption of sustainability as one would expect.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Land is not only a critical component of the earth's life support system, but also a precious resource and an important factor of production in economic systems. However, historical industrial operations have resulted in huge swathes of contaminated land that are only slowly being remediated. The US was estimated to have 294,000 hazardous waste sites needing cleanup (USEPA, 2004), and the European Environmental Agency (EEA) estimated that its member countries have 246,000 sites with soil contamination requiring cleanup (EEA, 2007). In the UK, England and Wales were estimated to have 33,500 contaminated sites (EA, 2005). These contaminated sites represent a huge risk to the welfare of current and future generations. Both the UK and the US governments have ambitious plans for cleaning up their tens to hundreds of thousands of contaminated sites within the next few decades (Rogers, 1999; USEPA, 2002). However, at the current investment pace, it may take many decades, if not centuries, to clean up these historical sites

* Corresponding author. Tel.: + 44 7774 955 082.
 E-mail address: deyi.hou@gmail.com (D. Hou).

(USEPA, 2004). It is imperative to develop technical solutions as well as socioeconomic and political instruments to achieve sustainable restoration of contaminated land while preventing the further contamination of existing clean lands (Hou, 2011; Hou et al., 2012b). While historically remediation focused on the removal and/or control of risks, there has been a recent shift towards sustainable practices within the remediation industry. The concept of "sustainable remediation" is increasingly accepted by remediation practitioners (Ellis and Hadley, 2009; Petruzzi, 2011; Lubrecht, 2012), as well as governments (CLARINET, 2002; USEPA, 2010; ITRC, 2011b) and academia (Harbottle et al., 2008; Sparrevik et al., 2012; Owsianiak et al., 2013; Hou et al., 2014). The inclusion of sustainability concepts in remediation decision-making also provides an opportunity to integrate a wide range of considerations: risk control, brownfield regeneration, carbon footprint, water footprint, renewable energy, etc.

There is considerable variability in the adoption of sustainability in remediation practice in various countries (Maurer, 2009). The UK plays a leading role in promoting sustainable remediation in Europe. In the most recent revision to the UK's contaminated land statutory guidance, a key policy objective was to ensure that the remediation burdens are "compatible with the principles of sustainable development" (DEFRA, 2012). Two UK based organizations, CLAIRE and Surf-UK, have been active in advocating sustainable remediation not only in the UK, but also Europe-wide. In 2010, Surf-UK, with coordination of CLAIRE and sponsorship from the Home and Communities Agency of the UK government, developed a framework for assessing the sustainability of remediation strategies (Surf-UK, 2010). The sustainable remediation agenda in the UK was also promoted by the urban renaissance movement. Driven by a public policy mandating that 60% of new housing development should be built on brownfield land, England had 79% of dwellings built on previously developed land in year 2008 (DCLG, 2009). The sustainable remediation, or green remediation, concept did not win recognition in the US until very recently. The presidential Executive Orders (EO) 13423 and 13514, issued in January 2007 and October 2009 respectively, promoted sustainable measures in federal agencies' operations. In 2008, the USEPA published a technology primer on green remediation that incorporates sustainable practices in contaminated site remediation (USEPA, 2008). It was followed by subsequent sustainable remediation initiatives in many other government agencies and industrial associations (DTSC, 2009; Ellis and Hadley, 2009; USEPA, 2009; Favara et al., 2011; Holland, 2011; Holland et al., 2011; ITRC, 2011b; USEPA Region 10, 2012; USEPA Region 2, 2012; USEPA Region 9, 2012; Illinois EPA, 2012; Minnesota PCA, 2012; Oregon DEQ, 2012). It should be noted that there are also differences in "green remediation" which is promoted by the USEPA and focuses on reducing environmental footprint of remediation operations, and "sustainable remediation" which is more widely accepted in Europe and incorporates social, economic, and environmental sustainability (ITRC, 2011b; Hou and Al-Tabbaa, 2014).

While many initiatives have taken place to promote sustainable behaviour in the remediation field, little is known on how effectively such sustainable behaviour has been adopted, and what may affect its adoption. In the present study, data from a survey of remediation practitioners was used to compare the adoption of sustainable remediation in the US and UK. The survey primarily focused on the US and the UK, mainly because these two countries have relatively large remediation markets and they both have shown strong interest in sustainable remediation, as evidenced by government policies and guidance (USEPA, 2008; ITRC, 2011b; DEFRA, 2012), as well as industrial initiatives in these two countries (Ellis and Hadley, 2009; Surf-UK, 2010). The survey also collected information on organizational properties, individual characteristics, institutional forces, and stakeholder influences. Subsequently, multivariate statistical analysis was conducted to identify potential determinants of the adoption of sustainable behaviour. This study aims to provide insights for sustainable behaviour, to researchers, policy makers, and practitioners, not only in the remediation field, but also in

the wider sustainability field. The present study is built on the social, economic and environmental tripartite model. It is recognized that many other sustainability models exist (Kates, 2010), but the tripartite model is selected due to its wide acceptance in the sustainable remediation community.

2. Materials and methods

2.1. Survey design

2.1.1. Sustainability considerations

Sustainability is an overarching concept with many practical implications. In the remediation field, various guidance documents, whitepapers, and policies have provided a wide range of sustainability considerations (EURODEMO, 2007; USEPA, 2008; Ellis and Hadley, 2009; Surf-UK, 2009; USACE, 2010; ITRC, 2011b). Based on an extensive review of existing literature, the present study identified 27 sustainability considerations, which were rated by respondents in the questionnaire survey (see Supporting Information [SI]). Some of these sustainability considerations tended to be generic. They were selected to maximize their potential of being incorporated into a wide range of contexts (e.g. across multiple countries and multiple work types). Consequently some specific sustainability practices, such as remedial process optimization (Hou and Leu, 2009), were not included in this survey. In addition, the selected sustainability considerations span across social, economic, and environmental spectrums. The survey question was "how effective is your team in adopting the following 'sustainability' considerations in developing remediation strategies?", and the responses were given on a 5-point scale (1: not at all – 5: very effective). It should be noted that this list of sustainability considerations was not built on a systematic and exclusive literature review; therefore, it by no means represents all potential sustainable remediation considerations. However, the authors believe that this list represents the majority of sustainable remediation considerations that are commonly accepted by the sustainable remediation community.

2.1.2. Internal characteristics and external forces

In the present study, potential determinants of sustainable behaviour were classified into two groups: internal characteristics and external forces. The internal characteristics represent the internal features that are associated with the decision maker (i.e. respondent), while the external forces represent the outside conditions faced by them. Internal characteristics studied in the present study covered three levels: the personal level (professional role, professional experience, and personal belief), organizational level (organization size, and organizational policy), and societal level (the US or the UK). Three types of external forces were measured in this survey: promoting factors, barriers, and stakeholder influences. For promoting factors, the survey question was "How important are the factors listed below in motivating your team to adopt sustainable practices in remediation?", and responses were given on a 5-point scale (1: not at all – 5: very important). For barriers, the survey question was "Have the following barriers impeded your team in adopting sustainable practices in remediation?", and responses were given on a 5-point scale (1: not at all – 5: very significant). Detailed descriptions of all these variables and the corresponding questionnaire items are provided in SI.

2.2. Survey procedure

The survey questionnaire was designed following extensive literature review on sustainable remediation, and according to general questionnaire survey guidance (Brace, 2004; Dillman, 2007; Saris and Gallhofer, 2007). The pilot questionnaire test was conducted with ten remediation practitioners and based on their feedback, the questionnaire was revised. A finalized survey questionnaire was setup online and emailed to potential survey participants. The survey included a

Table 1
Respondent characteristics.

Respondent types	Number of respondents (US)	Number of respondents (UK)
Total	112	54
Stakeholder type		
Site owner	7	4
Regulator	3	17
Primary consultant	68	18
Others (contractor, vendor, academic, etc)	34	15
Professional role type[a]		
Director	26	12
Project manager	49	17
Technical expert	59	27
Field worker	9	7

[a] Each respondent may have multiple professional roles.

consensus agreement at the beginning to ensure that confidentiality and anonymity are understood and that the survey participants are completing the survey on a voluntary basis. Potential survey participants included 1480 email contacts which were collected from personal contacts and online remediation publications, as well as two email lists for remediation professionals in the UK (JISCmail and CLAIRE) which included approximately 5500 listed members. A total of 223 effective responses (i.e. responses with more than 20 answers) was received from survey participants in 16 countries, with the majority received from the US (n = 112) and the UK (n = 54). Roughly 9.5% of email recipients (who may or may not have read the email) provided effective responses; and of the 357 individuals who accessed the questionnaire webpage, 62% provided effective responses. During the survey, it was recognized that many email addresses were probably not active email addresses, and many recipient from the email lists may not be reading the emails. Therefore, the above ratios only provide rough indication of response rate, and it may not be directly comparable to response rates in traditional mail survey.

Because there is no central database for remediation practitioners, it was not feasible to conduct random and representative sampling in the present survey. A convenience sampling approach was used in order to obtain a useful number of responses. It is likely that the survey participants may over-represent those who are interested in sustainable remediation, as well as high level decision makers. But this bias is expected to have limited effect on the comparison and correlation analysis, because this bias would be applicable to both the US and the UK practitioners. When comparing respondents from the US with those with the UK as for professional roles, they have similar representation, i.e. a similar percentage of high level decision makers, managers, technical staff, and field practitioners. When comparing the US and UK respondents as for stakeholder type, they have similar representation for site owner and other types, but the UK respondents over-represent

regulators while the US respondents over-represent primary consultants. Readers of this paper should be cautious about the conclusions drawn in the paper due to this bias in sample distribution. Table 1 shows the distribution of survey respondents and additional discussion regarding the sample representativeness is provided in SI.

2.3. Statistical analysis

The present study represents a quantitative analysis of sustainable remediation practice. It is built on existing qualitative studies that have been conducted by several organizations, including SURF, NICOLE, SURF-UK, and ITRC (Ellis and Hadley, 2009; NICOLE, 2009; Surf-UK, 2010; ITRC, 2011b). The quantitative analysis is considered a valuable supplement to existing qualitative literature because it provides confidence levels and statistical significance values in the testing of conclusions that can be drawn, as well as hypothesis that can be derived, from existing qualitative studies. In the present study, factor analysis (FA), a commonly used statistical technique in questionnaire development and analysis (Sharma and Henriques, 2005; Field, 2009), was used to establish latent constructs from questionnaire items. It extracts common factors from a large number of observed items by assuming these common factors had caused the manifest variables to covary. The factor analysis was conducted using the principle component method with varimax rotation to identify latent factors. The latent constructs identified by the FA were then used as dependent and predictor variables. This study used the general linear model (GLM) to examine the relationship between sustainability practices (i.e. dependent variables) and internal characteristics of the actors, as well as external forces (i.e. predictor variables). The statistical software SPSS was used to conduct the analysis (IBM Corp., 2010). The GLM was chosen over the multiple regression approach because GLM can analyse multiple variables at one time, and it is also capable of dealing with independent variables that are not linearly independent, as well as categorical predictor variables (Sharma and Henriques, 2005).

3. Results and discussion

3.1. Ranking and cross-country comparison of sustainable behaviour

Fig. 1 shows the rating of the adoption of 27 sustainability considerations by the US and UK remediation practitioners. The top three sustainability considerations were: "reducing site worker's risk", "protecting groundwater and surface water", and "reducing local community risk", which is consistent with the core value of existing decision making frameworks in contaminated land remediation (USEPA, 1988; EA, 2004). Social sustainability (e.g. "enhance local employment", "bring prosperity to disadvantaged community") and sustainable resource usage (e.g. "minimizing material use", "using sustainable energy") were ranked among the lowest, suggesting that these sustainability considerations have not

Table 2
Summary of latent constructs to measure sustainability.

Construct	Items	Reliability[a]
Social–economic sustainability		
Reduce remediation cost and time (RRCT)	Minimize long-term management; using fast-track remediation; reducing life-cycle cost	0.65
Increase development value (IDV)	Maximize area for redevelopment; increase property value	0.75
Social responsibility (SR)	Enhance local employment; bring prosperity to disadvantaged community; encourage public participation	0.68
Environmental sustainability		
Reducing immediate environmental impact (RIEI)	Minimizing waste generation; minimizing local scale secondary impact; reducing local community risk; minimizing risk to ecological systems; protect groundwater and surface water; protect habitat and ecosystem	0.83
Reducing distant environmental impact (RDEI)	Minimizing global scale secondary impact; minimizing water consumption; conserve natural resources; using environmental friendly products; minimizing energy use/maximize efficiency	0.86
Sustainable resource usage (SRU)	Enhancing reuse and recycling; using sustainable energy; minimizing material use; minimizing energy use/maximize efficiency; generating electricity from by-products	0.79

[a] For two-item scales, correlations are reported. For other scales, Cronbach's alpha is reported.

Table 3
Multivariate general linear model results of relationship between sustainability practices and intrinsic actor characteristics and external forces.

| Predictor variables	Environmental sustainability			Social/economic sustainability		
	Immediate environmental impact (RIEI)	Distant environmental impact (RDEI)	Sustainable resource usage (SRU)	Remediation cost/time (RRCT)	Development value (IDV)	Social responsibility (SR)
Intercept	2.81***	1.58***	1.00**	2.62***	2.75***	0.77
Country (US = 1, UK = 0)	−0.17	0.22	−0.17	0.20	−0.25	−0.01
Organizational context						
Organization size	0.04	−0.14	0.11	−0.20*	−0.03	−0.03
Organizational policy	0.05	0.17***	0.16***	0.13***	0.01	0.05
Individual characteristics						
Director	0.15	−0.05	−0.10	0.21	0.38**	0.24
Project manager	0.07	−0.06	0.03	0.05	0.11	0.35**
Technical specialist	0.12	0.04	−0.05	0.09	−0.07	0.01
Field decision maker	−0.18	−0.33*	−0.16	−0.42**	−0.40	−0.35*
Professional experience	0.00	−0.05	−0.02	0.31*	0.15	−0.29
Personal belief	0.12**	0.04	0.07	−0.04	0.07	0.07
Promoting factors						
Customer competitive pressure	0.15***	0.16**	0.10*	0.14**	0.28***	0.07
Social legitimacy pressure	0.20***	0.18**	0.12	−0.03	0.07	0.22**
Regulatory legitimacy pressure	−0.05	0.01	0.14**	0.01	−0.16*	0.09
Barriers						
Lack of institutional demand	−0.17***	−0.22***	−0.12*	0.04	0.03	−0.07
Lack of institutional resources	0.05	0.15*	0.05	−0.13	0.00	−0.03
Stakeholder influence						
Working parties	0.00	0.20**	0.17**	0.11	0.28**	0.07
Local community interest	−0.04	−0.06	0.01	0.02	−0.06	0.17*
Institutional field actors	−0.14**	−0.08	0.04	−0.03	−0.21**	−0.08
Primary stakeholders	0.11	−0.04	−0.13*	−0.03	0.01	0.11
R^2	0.33	0.40	0.43	0.28	0.20	0.33

Note: The number of observation is 166.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

been effectively adopted by current remediation practitioners. The lack of social sustainability may be attributed to the lack of knowledge and consensus on how to achieve social sustainability (EURODEMO, 2005; ITRC, 2011b). In comparison, sustainable resource usage is well recognized by green remediation best management practice (USEPA, 2008). Its lack of adoption may be attributed to a conflict between the technical feasibility and sustainability, i.e. the most feasible option tends to be energy intensive and resource consuming (Petruzzi, 2011).

While the US and UK remediation practitioners rendered similar ratings on most sustainability considerations, they also displayed discrepancies on some sustainability considerations. The most notable is regarding the usage of in-situ remediation rather than ex-situ remediation technologies: the US practitioners were much more effective than the UK practitioners in adopting this sustainable behaviour (4.27 vs. 3.39, p < 0.01). This is consistent with data from the US Superfund program, in which 47% of the 1107 source treatment projects from 1982 to 2008 composed of in-situ treatment (USEPA, 2013). In comparison, a recent UK Environment Agency (EA) publication showed that among a total of 781 sites determined as contaminated land under Part 2A in England and Wales by the end of March 2007, only approximately 4% projects proposed or used in-situ treatment (EA, 2009). This discrepancy may be partly attributed to CERCLA, the governing regulation
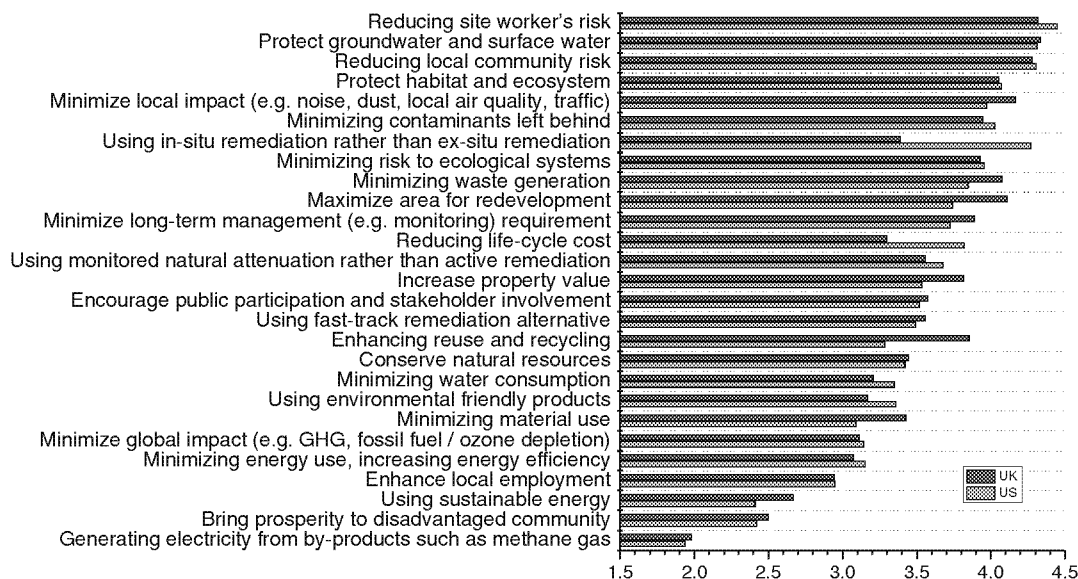
Fig. 1. Ranking the adoption of 27 sustainability considerations by remediation practitioners (Scales 1–5: 1 = not at all, 5 = very effective).
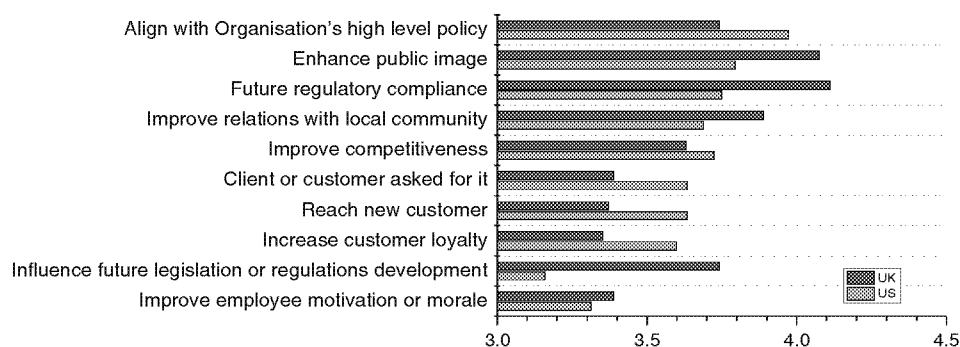
Fig. 2. Ranking of factors motivating sustainable practice in remediation (Scales 1–5: 1 = not important, 5 = very important).

of remediation in the US, as amended by SARA, expressing a strong preference to innovative treatment technologies (USEPA, 1989), as well as a strong technology research and demonstration program under this statuary regime, e.g. see Section 311 of CERCLA (2002). It is also likely due to the fact that traditionally remediation projects in the UK are primarily driven by development needs (Catney et al., 2006); consequently the remediation industry had preferred to fast-tracked ex-situ remediation technologies (most often dig and dump), rather than in-situ technologies which tend to be slower and render more uncertainty (Rivett et al., 2002). On the other hand, we expect that the dramatic increase of landfill tax from £7 per tonne in 1996 to £80 per tonne in 2014 (HMRC, 2013), and the phase out of contaminated land exemption of landfill tax in December 2008, will significantly increase the usage of in-situ treatment technology in the UK (2013).

The UK practitioners were more effective than the US practitioners in "enhancing reuse and recycling" (3.85 vs. 3.29, p < 0.01), and "minimizing material use" (3.43 vs. 3.09, p < 0.01). This is consistent with our observation that currently the UK remediation industry is actively diverting remediation waste from landfills by reusing or recycling such materials at other sites, mostly particularly under the Definition of Waste Code of Practice (DoWCoP) (CL:AIRE, 2011), which was developed by the professional organization CL:AIRE. According to a recent presentation by CL:AIRE, there had been 771 DoWCoP declarations since the launch of the original DoWCoP in 2008, likely involving the reuse of over 14 million m³ of material assuming an average declaration volume of 20,000 m³ (Willenbrock, 2013). This sustainable practice has largely been driven by the dramatic increase in landfill tax as discussed above. While reuse and recycling generally represent better practice, it could also potentially lead to new land contamination if not properly used (Hou, 2011; Hou et al., 2012a). Given the large volume of contaminated soil being diverted under DoWCoP, rigorous scientific study on its overall sustainability may be warranted.

3.2. Promoters of sustainable remediation

Ten sustainability promoting factors were ranked (see Fig. 2), of which the top three were: "align with organization's high level policy", "enhance public image", and "future regulatory compliance". It should be noted that the US practitioners gave a much higher rating for "align with organization's high level policy" than the UK practitioners. The US practitioners also gave higher ranking on several market oriented items: "improve competitiveness", "client or customer asked for it", "reach new customer", and "increase customer loyalty". In comparison, the UK practitioners gave much higher rating for regulatory factors (e.g. "future regulatory compliance" and "influence future legislation or regulations development") and social factors (e.g. "enhance public image" and "improve relations with local community"). These contrasts suggest that sustainable remediation in the US is more strongly driven by market forces and organizational policies, while sustainable remediation in the UK is more strongly driven by expected change in regulations and the pressures of social legitimacy.

3.3. Barriers of sustainable remediation

The three most influential sustainability barriers were: "no regulatory mandate", "lack of client demand", and "cost considerations" (see Fig. 3). A 2008 survey of SURF members and US regulators also identified the lack of regulatory driver as being the most significant barrier (Ellis and Hadley, 2009), suggesting this perception did not change over the past five years despite significant progress being made over this period. Although many advocates believe that sustainable remediation should save cost, this study and a previous survey both suggest that in common perception green and sustainable remediation (GSR) will add cost (ITRC, 2011a). The "lack of simple tools" and "lack of awareness" were ranked low, especially by the US practitioners, which may reflect the
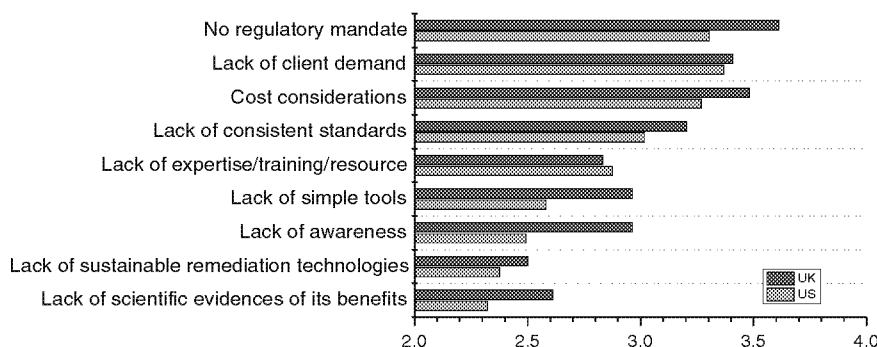

Fig. 3. Ranking of barriers impeding sustainable practice in remediation (Scales 1–5: 1 = not at all, 5 = very significant).

fact that some simple footprint calculation tools have been developed by various US government agencies, such as SRT (AFCEE, 2010), SiteWise (NAVFAC, 2011), and USEPA's calculation sheet (USEPA, 2012a,b). In addition, many federal and statement governments in the US are promoting green and/or sustainable remediation (DTSC, 2009; USEPA, 2009; Illinois EPA, 2012; Minnesota PCA, 2012; Oregon DEQ, 2012; USEPA Region 10, 2012; USEPA Region 2, 2012; USEPA Region 9, 2012). Lack of sustainable remediation technology and scientific evidence were also ranked low, suggesting it is mainly social–economic and policy factors, rather than technological factors which are impeding sustainable remediation.

3.4. Determinants of sustainable behaviour

Factor analysis identified six latent constructs to measure sustainability in remediation (see Table 2 for the list of constructs, items, and reliability). Most alpha coefficients were near or above 0.7, a threshold recommended by Nunnally and Bernstein (Nunnally and Bernstein, 1994), suggesting that our categorization was relatively robust. Among these six constructs, three constructs measure the social and economic sustainability: reduce remediation cost and time (RRCT), increase development value (IDV), and social responsibility (SR); and the other three constructs measure the environmental sustainability: reduce immediate environmental impact (RIEI), reduce distant environmental impact (RDEI), and sustainable resource usage (SRU). The following subsections present the determinant analysis results using the GLM method.

3.4.1. Internal characteristics

As shown in Table 3, the most influential internal characteristic is the extent to which the organization's sustainability policy is applicable to remediation practices. This factor has significant positive effect on RDEI ($p < 0.01$), SRU ($p < 0.01$), and RRCT ($p < 0.01$). These results have strong implications. Consistent with the direct ranking of promoting factors discussed in Section 3.2, which indicates that "align with organization's high level policy" was the number one promoting factor, the GLM results further verified the importance of organizational policy through a correlation analysis. The ranking of promoting factors is based on the direct perception of respondents; therefore it does not necessarily reflect the actual effect of the factors (i.e. respondents might "think" a factor has impact but actually it does not). In addition, the ranking may be subjected to perception bias (e.g. a factor is more often heard and therefore considered more important). In comparison, the GLM analysis measures the co-variation of each factor and sustainable behaviour; therefore it provides separate and stronger evidence on the effect of organizational policy.

Existing studies have shown that sustainability and pro-environmental behaviour in an organizational setting is positively linked to organizational policy (Ramus and Steger, 2000; Manring and Moore, 2006). A case study on sustainable remediation also indicated that facility's corporate mission statement had positive effect on incorporating GSR (Petruzzi, 2011). However, there may be discrepancies between pro-environmental policy and its implementation: policy statements are easy to make but policy implementation takes serious effort. Without a business rationale for the implementation of environmental policy, such commitment may simply be "greenwashing" (Ramus and Montiel, 2005). Ramus and Montiel have argued that the inclusion of specific environmental subpolicies is important for its implementation (Ramus and Montiel, 2005). Our study confirmed this claim by showing that the relevance of organizational policy to sustainable remediation practice played an important role in its implementation. More importantly, our study showed that such relevant policy can have far more significant effect than other factors such as professional role, experience, and personal belief. This echoes with previous finding that sustainability in production was "not so much a matter of

diagnostics and technology as it was using policy management with performance-based standards" (Manring and Moore, 2006).

Professional roles were also found to have some significant effects. The professional role was found to influence professional's view on environmental issues, regardless of organizational association (Von Borgstede and Lundqvist, 2006). In the present study, directors were found to adopt the IDV measure more often ($p < 0.05$), suggesting this group of professionals are likely to be more business oriented (i.e. caring more about the value adding activities in planning and redevelopment). Project managers were found to have a significant positive effect in adopting SR, suggesting that project managers are probably more involved in activities aiming at enhancing the social legitimacy of remedial projects (e.g. public participation). In contrast with director and project manager, field decision maker was found to have negative effect on several sustainability measures, most notably RRCT ($p < 0.05$), but also RDEI ($p < 0.1$) and SR ($p < 0.1$). While sustainable remediation guidance considers it important to communicate GSR procedures to field staff (ITRC, 2011a), our results suggest that making a sustainable decision can be extremely difficult in the field. Field work usually involves a complicated environment, and it demands for quick decision making on many issues. Moreover, quite often other issues such as progress delay, health and safety, are considered far more important and can take full attention of field decision makers. This conflict between sustainable behaviour and field decision making warrants further exploration in order to more effectively adopt GSR measures on the ground.

The effects of personal belief (i.e. personal view of the importance of sustainability in remediation) were expected to be significant. However, it was found to be significant only for RIEI ($p < 0.05$). It could likely be due to two reasons: 1) the perception of sustainability by most remediation practitioners still focuses on environmental impact with spatial or temporal immediacy; and 2) personal belief plays a less important role in organizational behaviour than in individual behaviour, in which environmental behaviour studies have shown paramount importance of personal belief (Grob, 1995; Kollmuss and Agyeman, 2002).

3.4.2. External forces

Three types of external forces were examined: promoting factors, barriers, and stakeholder influence. Latent constructs were used to reduce the number of predictor variables. Factor analysis identified three constructs for promoting forces, two constructs for barriers, and four constructs for stakeholder influence (see SI). The GLM results identified the four most important external forces: customer competitive pressure (with significant effects on five of six sustainability measures), social legitimacy pressure, lack of institutional demand, and stakeholder influence from working parties (with significant effects on three of six sustainability measures for each of these last three forces).

Customer competitive pressure had the most significant effect on RIEI ($p < 0.01$) and IDV ($p < 0.01$), suggesting this market force is very effective in promoting sustainability considerations that aim at reducing immediate environmental impact (e.g. minimizing local secondary impact like noise, dust, and air pollutant), as well as considerations to increase property and development values. This is straightforward because the customer competitive pressure originates from the client's demand, which calls for action to enhance its "social license to operate" in a local context (Gunningham et al., 2004), and which also wants to ensure their "economic bottom line" (Elkington, 1998; Hillman and Keim, 2001). Customer competitive pressure also had significant effect on RDEI ($p < 0.05$) and RRCT ($p < 0.05$), and slightly significant effect on SRU ($p < 0.1$), for similar reasons discussed above. These effects were slightly less significant, probably because these sustainability considerations are temporarily or spatially more distant (RDEI and SRU vs. RIEI), or corresponding to smaller amount of monetary value (i.e. RRCT vs. IDV). On the other hand, customer competitive pressure did not have significant effect on SR, suggesting that the improvement in addressing the social responsibility issue in remediation currently is not directly originated from client demand.

Social legitimacy pressure had significant effects on RIEI ($p < 0.01$), RDEI ($p < 0.05$), and SR ($p < 0.05$). Studies have found that the social legitimacy of remediation projects attributes to perceived openness and motives (Eiser et al., 2007), transparency (Sparrevik et al., 2011), as well as the social acceptability of remedial technology (Wolfe et al., 2003). It is straightforward that the social legitimacy pressure enhances the adoption of social responsibility measure (Waddock et al., 2002). Social legitimacy pressure reduced both immediate environmental impact and distant environmental impact, likely due to the fact that this pressure originates from both local community and the public in larger context (e.g. the media) (Brown and Deegan, 1998). Regulatory legitimacy pressure had significant positive effect on SRU ($p < 0.05$) and slightly negative effect on IDV ($p < 0.1$), suggesting that remediation practitioners expect future legislation to become more friendly to sustainable resource usage (e.g. reuse, recycling, sustainable energy), but probably less friendly to redevelopment on brownfield. The later effect, even though only significant at a 0.1 significance level, is rather interesting. Industry observers indicated that the UK is undergoing a quiet policy shift from focusing on brownfield redevelopment to allowing for more greenfield development. Our results may partly reflect that change.

The lack of institutional demand had significant negative effect on RIEI ($p < 0.01$), RDEI ($p < 0.01$), and slightly significant negative effect on SRU ($p < 0.1$). This lack of institutional demand is a class of barriers that are related to the demand side, which may originate from lack of awareness, lack of regulatory mandate, etc. The GLM results suggested that the barrier on the demand side mainly impeded the adoption of environmental sustainability measures, but not so much on the social and economic sustainability measures. It is likely because the current sustainable remediation movement has primarily focused on reducing secondary environmental effect with much less attention to social and economic sustainability (ITRC, 2011a). Consequently the demand for sustainable remediation had been interpreted to be mainly associated with adverse environmental impacts, leading to a lack of correlation of this barrier with social and economic sustainability.

Four types of stakeholder influence were identified by factor analysis: working parties, local community interest, institutional field actors, and primary stakeholders. The working parties included all consultants (excluding primary consultant), contractors, and vendors. Their influence was found to be the most significant among all four types of stakeholders, with positive correlation with RDEI ($p < 0.05$), SRU ($p < 0.05$), and IDV ($p < 0.05$), even though their direct ranking was among the lowest (see SI). In comparison, primary stakeholders (site owner, primary consultant, regulator, top management) were perceived to have strong influence (i.e. high direct ranking), but they did not have significant correlation with sustainable behaviour. These results suggest a gap between perception and practice in stakeholder influence. Moreover, the stakeholder influence did not seem to have as strong and extensive effect as one would expect. This lack of significant direct effect of stakeholder influence on organizational environmental behaviour has also been observed in some other studies (Hussey and Eagan, 2007). According to the present study and existing literature, we posit that decision making in an organization, especially decision making in infrastructure engineering projects, tends to be affected more by factual knowledge based institutional norms and pressures, rather than direct stakeholder influence, partly due to a lack of rigorous stakeholder involvement in most engineering projects.

4. Conclusions

This study presented a cross country (US vs. UK) comparison and determinant analysis of sustainable remediation, based on perceptions by key decision makers representing the site owner, regulator, primary consultant, contractor and others. A questionnaire survey was conducted, and quantitative analysis was performed using factor analysis and general linear modelling. Survey results indicated that the US

and UK remediation practitioners rendered similar ratings on the adoption of most sustainability considerations, with the overall top three sustainable behaviours being: "reducing site worker's risk", "protecting groundwater and surface water", and "reducing local community risk". Social sustainability and sustainable resource usage were ranked among the lowest. In comparing the two countries, the US practitioners were much more effective than the UK practitioners in adopting the usage of in-situ remediation, while the UK practitioners were more effective than the US practitioners in "enhancing reuse and recycling" and "minimizing material use".

Both internal characteristics and external forces were found to affect the adoption of sustainable behaviour in remediation. In the ranking directly provided by respondents, the overall top three promoting factors were: "align with organization's high level policy", "enhance public image", and "future regulatory compliance"; and the three most influential sustainability barriers were: "no regulatory mandate", "lack of client demand", and "cost considerations". The GLM analysis provides more robust results on the effect of potential determinants. It was found that organizational policy was the most significant internal characteristic with positive effects primarily on RDEI, SRU, and RRCT. Customer competitive pressure was the most significant external force with positive effects on nearly all sustainability categories. Stakeholders' influence, especially that from primary stakeholders (site owner, regulator, and primary consultant), did not have significant and extensive effects on sustainable behaviour.

The results of this survey analysis have significance not only for contaminated site remediation, but also for the wider context of sustainability science and sustainability practice. We have identified the following implications, in the hope that they will assist policy makers to develop effective policy instruments, as well as helping sustainability practitioners to efficiently promote sustainable practice:

1) Factors affecting behaviour in intermediate consumption (goods or services used in production by enterprises), which is usually decided by professionals, can be very different from behaviour in consumer consumption, which is usually decided by individual customers. While personal experience and personal belief can be extremely important in determining personal behaviour, they were found to be far less important than organizational policy in affecting organizational behaviour, suggesting that sustainable behaviour in an organizational setting may be mainly decided by institutional characteristics, rather than personal characteristics. As intermediate consumption can account for nearly half of gross industrial output (ONS, 2012), it is imperative to conduct rigorous scientific studies to identify the mechanisms that determine the adoption of pro-environmental and sustainability behaviour in organizational settings, and then to incorporate such understandings into policy making.

2) Historically the UK remediation industry was largely driven by development needs and also mostly governed by planning authorities; this societal and regulatory context has promoted the dominant usage of some unsustainable practices such as dig and dump. A most recent change in landfill tax regime may significantly discourage dig and dump, and promote innovative in-situ treatment technologies. Both examples strongly suggest that the choice of socioeconomic and policy instruments can significantly affect organizational behaviour, which determines the ultimate sustainability of collective action on an industry level. Therefore, informed decision by regulators and policy makers is important.

3) Lack of sustainable technologies was not perceived to be an important barrier, and lack of institutional resources was not found to be negatively correlated with sustainable behaviour. These results imply that it was not technological factors which limited the adoption of sustainability measures. It is rather the "soft" factors (e.g. social pressure, market force, organizational environment) which may limit the wide spread of sustainable behaviour in remediation.

4) Field workers were found to adopt sustainable behaviour less effectively, suggesting that improvement in the field implementation of sustainable behaviour is much needed. This can be applied to a wide range of contexts because the factors affecting field workers in the remediation field (e.g. time constraint, safety concern) may also affect field workers in other types of business.

5) Stakeholders' influence was not as effective as one would expect. It is likely due to the fact that stakeholder engagement in remediation decision making is still very limited. But it is also possible that institutional forces are more influential than stakeholder forces in driving sustainable behaviour. The effect of stakeholder engagement in promoting the sustainability agenda is worth further exploration.

The present study also has several limitations. First of all, the readers are warned of the limitations of sampling bias as discussed in Section 2.2. Even though it has not been identified, it was likely that certain sampling bias may explain some of the observed discrepancies between the US and UK responses. Secondly, while the statistical significance tests are objective, the interpretation of the present results is subject to confirmation bias. Interested readers are suggested not only to read the texts, but also to explore the numerical results presented in the figures and tables to obtain their own interpretation. Thirdly, the survey data largely represent "perceived" results rather than "measured" results. Therefore, the interpretation of the results must take into account this "perception" component.

Acknowledgement

Appendix A. Supplementary data

Text, tables and figures addressing materials and methods and supporting data and results are available as Supporting Information. Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.scitotenv.2014.05.059.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.scitotenv.2014.05.059.

References

AFCEE. Sustainable remediation tool user guide. Lackland, Texas: AFCEE, Air Force Center for Engineering and the Environment; 2010.

Brace I. Questionnaire design: how to plan, structure, and write survey material for effective market research. London & Sterling, VA: Kogan Page Ltd.; 2004.

Brown N, Deegan C. The public disclosure of environmental performance information — a dual test of media agenda setting theory and legitimacy theory. Account Bus Res, 29(1). Taylor & Francis; 1998. p. 21–41.

Catney P, Henneberry J, Meadowcroft J, Eiser JR. Dealing with contaminated land in the UK through development managerialism. J Environ Policy Plan, 8(4). Taylor & Francis; 2006. p. 331–56.

CERCLA. Comprehensive Environmental Response, Compensation, and Liability Act Of 1980 (Superfund), as amended through P.L; 2002. p. 107–377.

CL:AIRE. The definition of waste: development industry code of practice; 2011.

CLARINET. Sustainable management of contaminated land: an overview. CLARINET. Contaminated Land Rehabilitation Network for Environmental Technologies; 2002 (succeeded by Common Forum on Contaminated Land in the European Union).

Corp IBM. IBM SPSS statistics for windows, version 19.0. Armonk, NY: IBM Corp.; 2010.

DCLG. Land use change statistics (England) 2008 — provisional estimates (July 2009) [Internet]. London, UK: DCLG, Department for Communities and Local Government; 2009 [Available from: www.communities.gov.uk/publications/corporate/statistics/lucs2008provisionaljuly].

DEFRA. Environmental Protection Act 1990: part 2A contaminated land statutory guidance. London, UK: Department for Environment, Food and Rural Affairs; 2012.

Dillman DA. Mail and internet surveys: the tailored design method. John Wiley & Sons; 2007.

DTSC. Interim advisory for green remediation. Sacramento, CA: DTSC, Department of Toxic Substances Control; 2009.

EA. Model procedures for the management of land contamination. Contaminated Land Report 11 [Internet]. London, UK: EA, Environment Agency; 2004 [Available from: http://publications.environment-agency.gov.uk/PDF/SCHO0804BIBR-E-E.pdf].

EA. Indicators for land contamination. Science Report SC030039/SR [Internet]. London, UK: EA, Environment Agency; 2005 [Available from: http://publications.environment-agency.gov.uk/PDF/SCHO0805BJMD-E-E.pdf].

EA. Reporting the evidence: dealing with contaminated land in England and Wales — a review of progress from 2000–2007 with part 2A of the Environmental Protection Act. Bristol, UK: Environment Agency; 2009.

EEA. Progress in management of contaminated sites (CSI 015) — assessment published Aug 2007 [Internet] European Environment Agency; 2007 [Available from: http://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites/progress-in-management-of-contaminated-1].

Eiser JR, Stafford T, Henneberry J, Catney P. Risk perception and trust in the context of urban brownfields. Environ Hazards, 7(2). Elsevier; 2007. p. 150–6.

Elkington J. Partnerships from cannibals with forks: the triple bottom line of 21st-century business. Environ Qual Manag, 8(1). Wiley Online Library; 1998. p. 37–51.

Ellis DE, Hadley PW. Sustainable remediation white paper — integrating sustainable principles, practices, and metrics into remediation projects. Remediat J, 19(3). Wiley Online Library; 2009. p. 5–114.

EURODEMO. Status report on decision making processes and criteria. European Co-ordination Action for Demonstration of Efficient Soil and Groundwater Remediation; 2005.

EURODEMO. Framework for sustainable land remediation and management. European Co-ordination Action for Demonstration of Efficient Soil and Groundwater Remediation; 2007.

Favara PJ, Krieger TM, Boughton B, Fisher AS, Bhargava M. Guidance for performing footprint analyses and life-cycle assessments for the remediation industry. Remediat J, 21(3). Wiley Online Library; 2011. p. 39–79.

Field A. Discovering statistics using SPSS. Third. London, UK: Sage Publications Limited; 2009.

Grob A. A structural model of environmental attitudes and behaviour. J Environ Psychol, 15(3). Elsevier; 1995. p. 209–20.

Gunningham N, Kagan RA, Thornton D. Social license and environmental protection: why businesses go beyond compliance. Law Soc Inq, 29(2). Wiley Online Library; 2004. p. 307–41.

Harbottle MJ, Al-Tabbaa A, Evans CW. Sustainability of land remediation: part I: overall analysis. Proc Inst Civ Eng Eng, 161(2). Telford; 2008. p. 75–92.

Hillman AJ, Keim GD. Shareholder value, stakeholder management, and social issues: what's the bottom line? Strateg Manag J 2001;22(2):125–39.

HMRC. A general guide to landfill tax [Internet]. [cited 2013 Nov 10]. Available from: http://www.hmrc.gov.uk/; 2013.

Holland KS. A framework for sustainable remediation. Environ Sci Technol 2011;45(17): 7116–7. [[Internet]. Available from: http://pubs.acs.org/doi/abs/10.1021/es202595w].

Holland KS, Lewis RE, Tipton K, Karnis S, Dona C, Petrovskis E, et al. Framework for integrating sustainability into remediation projects. Remediat J, 21(3). Wiley Online Library; 2011. p. 7–38.

Hou D. Vision 2020: more needed in materials reuse and recycling to avoid land contamination. Environ Sci Technol 2011;45(15):6227–8.

Hou D, Al-Tabbaa A. Sustainability: a new imperative in contaminated land remediation. Environ Sci Pol 2014;39(5):25–34.

Hou D, Leu RJ. Optimizing the remedial process at a petroleum hydrocarbon contaminated site using a three-tier approach. J Environ Eng 2009;135:1171.

Hou D, Al-Tabbaa A, Guthrie P, Watanabe K. Sustainable waste and materials management: national policy and global perspective. Environ Sci Technol 2012a;46(5): 2494–5.

Hou D, Luo J, Al-Tabbaa A. Shale gas can be a double-edged sword for climate change. Nat Clim Chang, 2(6). Nature Publishing Group; 2012b. p. 385–7.

Hou D, Al-Tabbaa A, Luo J. Assessing effects of site characteristics on remediation secondary life cycle impact with a generalized framework. J Environ Plan Manag 2014;57(7).

Hussey DM, Eagan PD. Using structural equation modeling to test environmental performance in small and medium-sized manufacturers: can SEM help SMEs? J Clean Prod, 15(4). Elsevier; 2007. p. 303–12.

Illinois EPA. Greener cleanups: how to maximize the environmental benefits of site remediation [Internet] Illinois Environmental Protection Agency; 2012 [[cited 2012 Jan 24]. Available from: http://www.epa.state.il.us/land/greener-cleanups/matrix.pdf].

ITRC. Green and sustainable remediation: a practical framework. Washington, DC: Interstate Technology & Regulatory Council; 2011a.

ITRC. Green and sustainable remediation: state of the science and practice. ITRC. Washington, DC, USA: Interstate Technology & Regulatory Council; 2011b.

Kates RW. Readings in sustainability science and technology. CID Working Paper No. 213; 2010.

Kollmuss A, Agyeman J. Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res, 8(3). Taylor & Francis; 2002. p. 239–60.

Lubrecht MD. Horizontal directional drilling: a green and sustainable technology for site remediation. Environ Sci Technol 2012;46(5):2484–9. [[Internet], Available from: http://pubs.acs.org/doi/abs/10.1021/es203765q].

Manring SL, Moore SB. Creating and managing a virtual inter-organizational learning network for greener production: a conceptual model and case study. J Clean Prod, 14(9). Elsevier; 2006. p. 891–9.

Maurer O. NICOLE's shared vision on sustainable remediation. Green Remediat Conf. Copenhagen, Denmark; 2009.

Minnesota PCA. Toolkit for greener practices: learn more about the initiative-toolkit rationale and concept [Internet] Minnesota Pollution Control Agency; 2012 [[cited 2012 Jan 24]. Available from: http://www.pca.state.mn.us/index.php/view-document.html?gid=5405].

NAVFAC. SiteWise version 2 user guide. NAVFAC. Port Hueneme, CA: Naval Facilities Engineering Command, Engineering Service Center; 2011.

NICOLE. Report of the NICOLE workshop: sustainable remediation — a solution to an unsustainable past? NICOLE. Utrecht, The Netherlands: Network for Industrially Contaminated Land in Europe; 2009.

Nunnally JC, Bernstein IH. Psychometric theory. 3rd ed. New York: McGraw-Hill; 1994.

ONS. Input–output supply and use tables [Internet] 2012 ed. Office for National Statistics; 2012 [[cited 2013 Mar 8]. Available from: http://www.ons.gov.uk/ons/rel/input-output/input-output-supply-and-use-tables/2012-edition/index.html].

Oregon DEQ. Green remediation policy [Internet] Oregon Department of Environmental Quality; 2012 [[cited 2012 Jan 26]. Available from: http://www.deq.state.or.us/lq/pubs/docs/cu/GreenRemediationPolicy.pdf].

Owsianiak M, Lemming G, Hauschild MZ, Bjerg PL. Assessing environmental sustainability of remediation technologies in a life cycle perspective is not so easy. Environ Sci Technol 2013;47(3):1182–3. [Internet], Available from: http://pubs.acs.org/doi/abs/10.1021/es305279t.

Petruzzi NM. A case study on the evaluation and implementation of green and sustainable remediation principles and practices during a RCRA corrective action cleanup. Ground Water Monit Remediat. Wiley Online Library; 2011.

Ramus CA, Montiel I. When are corporate environmental policies a form of greenwashing? Bus Soc, 44(4). Sage Publications; 2005. p. 377–414.

Ramus CA, Steger U. The roles of supervisory support behaviors and environmental policy in employee "ecoinitiatives" at leading-edge European companies. Acad Manag J JSTOR 2000;43(4):605–26.

Rivett MO, Petts J, Butler B, Martin I. Remediation of contaminated land and ground-water: experience in England and Wales. J Environ Manage, 65(3). Elsevier; 2002. p. 251–68.

Rogers Lord, editor. Towards an urban renaissance: Report by the Urban Task Force. DETRLondon, UK: Department of the Environment, Transport and the Regions; 1999.

Saris WE, Gallhofer IN. Design, evaluation, and analysis of questionnaires for survey research. Wiley-Interscience; 2007.

Sharma S, Henriques I. Stakeholder influences on sustainability practices in the Canadian forest products industry. Strateg Manag J, 26(2). Wiley Online Library; 2005. p. 159–80.

Sparrevik M, Ellen GJ, Duijn M. Evaluation of factors affecting stakeholder risk perception of contaminated sediment disposal in Oslo Harbor†. Environ Sci Technol 2011;45(1): 118–24. [[Internet], Available from: http://pubs.acs.org/doi/abs/10.1021/es100444t].

Sparrevik M, Barton DN, Bates ME, Linkov I. Use of stochastic multi-criteria decision analysis to support sustainable management of contaminated sediments. Environ Sci Technol 2012;46(3):1326–34. [[Internet], Available from: http://pubs.acs.org/doi/abs/10.1021/es202225x].

Surf-UK. A review of published sustainability indicator sets: how applicable are they to contaminated land remediation indicator-set development? London, UK: Contaminated Land: Applications in Real Environments (CL:AIRE); 2009.

Surf-UK. A framework for assessing the sustainability of soil and groundwater remediation. CLAIRE. London, UK: Contaminated Land: Applications in Real Environments; 2010.

USACE. Decision framework for incorporation of green and sustainable practices into environmental remediation projects. Washington, DC: USACE, United States Army Corps of Engineers; 2010.

USEPA. Guidance for conducting remedial investigations and feasibility studies under CERCLA (Interim Final). EPA/540/G-89/004 Washington, DC: USEPA, United States Environmental Protection Agency; 1988.

USEPA. Advancing the use of treatment technologies for superfund remedies; 1989.

USEPA. Beyond RCRA — waste and materials management in the year 2020, EPA530-R-02-009. Washington, DC: USEPA, United States Environmental Protection Agency; 2002.

USEPA. Cleaning up the nation's waste sites: markets and technology trends. 2004 ed. Washington, DC: United States Environmental Protection Agency; 2004.

USEPA. Green remediation: incorporating sustainable environmental practices into remediation of contaminated sites. EPA 542-R-08-002 Washington, DC: USEPA, United States Environmental Protection Agency; 2008 [Apr.].

USEPA. Principles for greener cleanups [Internet] United States Environmental Protection Agency, Office of Solid Waste and Emergency Response; 2009 [Available from: http://www.epa.gov/oswer/greenercleanups/pdfs/oswer_greencleanup_principles.pdf].

USEPA. Superfund green remediation strategy. Washington, DC: USEPA, United States Environmental Protection Agency; 2010.

USEPA. Methodology for understanding and reducing a project's environmental footprint, EPA 542-R-12-002; 2012a.

USEPA. SEFA: spreadsheets for environmental footprint analysis; 2012b.

USEPA. Superfund remedy report. EPA 542-R-13-016Fourteenth ed. Washington, DC, USA: United States Environmental Protection Agency; 2013 [Nov].

USEPA Region 10. Green cleanups [Internet]. [cited 2012 Jan 23]. Available from: http://yosemite.epa.gov/R10/extaff.nsf/programs/greencleanups, 2012.

USEPA Region 2. Region 2 green remediation [Internet]. [cited 2012 Jan 23]. Available from: http://www.epa.gov/region02/superfund/green_remediation/, 2012.

USEPA Region 9. Clean energy & climate change green site cleanups [Internet]. [cited 2012 Jan 23]. Available from: http://www.epa.gov/region9/climatechange/green-sites. html, 2012.

Von Borgstede C, Lundqvist LJ. Organizational culture, professional role conceptions and local Swedish decision-makers' views on climate policy instruments. J Environ Policy Plan, 8(4). Taylor & Francis; 2006. p. 279–92.

Waddock SA, Bodwell C, Graves SB. Responsibility: the new business imperative. Acad Manag Exec JSTOR 2002;16(2):132–48.

Willenbrock N. CL:AIRE definition of waste code of practice (DoWCoP) uptake — facts & figures. 2013 CLAIRE Annu Conf — Sustain L Manag; 2013.

Wolfe AK, Bjornstad DJ, Kerchner ND. Making decisions about hazardous waste remediation when even considering a remediation technology is controversial. Environ Sci Technol 2003;37(8):1485–92. [[Internet], Available from: http://pubs.acs.org/doi/abs/10.1021/es015659z].